Combined Gas Law Problems

1) A sample of sulfur dioxide occupies a volume of 652 mL at 40.° C and 720 mm Hg. What volume will the sulfur dioxide occupy at STP?

2) A sample of argon has a volume of 5.0 dm$^3$ and the pressure is 0.92 atm. If the final temperature is 30.° C, the final volume is 5.7 L, and the final pressure is 800. mm Hg, what was the initial temperature of the argon?

3) 322 L of hydrogen occupies a volume of 197 L at STP. If the initial temperature of the hydrogen was 37° C, what was its initial pressure?

4) The initial temperature of a 1.00 liter sample of argon is 20.° C. The pressure is decreased from 720 mm Hg to 360 mm Hg and the volume increases to 2.14 liters. What was the change in temperature of the argon?

5) A sample of nitrogen gas occupies a volume of 2.00 L at 756 mm Hg and 0.00° C. The volume increases by 2.00 L and the temperature decreases to 137 K. What is the final pressure exerted on the gas?

6) A 20. L container is filled with helium and the pressure is 150 atm and the temperature is 30.° C. How many 5.0 L balloons can be filled when the temperature is 22° C and the atmospheric pressure is 755 mm?
Solutions

1) \[ P_1 = 720 \text{ mm} \quad \quad P_2 = 760 \text{ mm} \]
\[ V_1 = 652 \text{ mL} \quad \quad V_2 = ? \]
\[ T_1 = 40.\, ^\circ \text{C} + 273 = 313 \text{ K} \quad \quad T_2 = 0\, ^\circ \text{C} + 273 = 273 \text{ K} \]

\[ \frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2} \]
\[ V_2 = \frac{P_1 V_1}{T_1} \times \frac{T_2}{P_2} \]
\[ V_2 = 720 \text{ mm} \times 652 \text{ mL} \times 273 \text{ K} / (313 \text{ K} \times 760 \text{ mm}) = 540 \text{ mL SO}_2 \]

2) \[ P_1 = 0.92 \text{ atm} \quad \quad P_2 = 800. \text{ mm} \]
\[ V_1 = 5.0 \text{ dm}^3 \quad \quad V_2 = 5.7 \text{ L} \]
\[ T_1 = ? \quad \quad T_2 = 30.\, ^\circ \text{C} + 273 = 303 \text{ K} \]

\[ \frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2} \]
\[ T_1 = \frac{P_1 V_1}{P_2} \times \frac{T_2}{V_2} \]
\[ T_1 = 0.92 \text{ atm} \times 760 \text{ mm} / 1 \text{ atm} \times 5.0 \text{ dm}^3 \times 303 \text{ K} / (800. \text{ mm} \times 5.7 \text{ L} \times 1 \text{ dm}^3 / \text{L}) = 232 \text{ K} = -41\, ^\circ \text{C} \]

3) \[ P_1 = ? \quad \quad P_2 = 1.00 \text{ atm} \]
\[ V_1 = 322 \text{ L} \quad \quad V_2 = 197 \text{ L} \]
\[ T_1 = 37\, ^\circ \text{C} + 273 = 310 \text{ K} \quad \quad T_2 = 0\, ^\circ \text{C} + 273 = 273 \text{ K} \]

\[ \frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2} \]
\[ P_1 = \frac{P_2 V_2}{T_2} \times \frac{T_1}{V_1} \]
\[ P_1 = 1.00 \text{ atm} \times 197 \text{ L} \times 310 \text{ K} / (273 \text{ K} \times 322 \text{ L}) = 0.69 \text{ atm} \]
4) \( P_1 = 720 \text{ mm} \quad P_2 = 360 \text{ mm} \)

\( V_1 = 1.00 \text{ L} \quad V_2 = 2.14 \text{ L} \)

\( T_1 = 20.^{\circ} \text{ C} + 273 = 293 \text{ K} \quad T_2 = ? \)

\[
P_1V_1/T_1 = P_2V_2/T_2
\]

\[
T_2 = P_2V_2/P_1 \times T_1/V_1
\]

\[
T_2 = 360 \text{ mm} \times 2.14 \text{ L} \times 293 \text{ K} / (720 \text{ mm} \times 1.0 \text{ L}) = 313 \text{ K} = 40.^{\circ} \text{ C}
\]

5) \( P_1 = 756 \text{ mm} \quad P_2 = ? \)

\( V_1 = 2.00 \text{ L} \quad V_2 = 4.00 \text{ L} \)

\( T_1 = 0.0^{\circ} \text{ C} + 273 = 273 \text{ K} \quad T_2 = 137 \text{ K} \)

\[
P_1V_1/T_1 = P_2V_2/T_2
\]

\[
P_2 = P_1V_1/T_1 \times T_2/V_2
\]

\[
P_2 = 756 \text{ mm} \times 2.00 \text{ L} \times 137 \text{ K} / (273 \text{ K} \times 4.00 \text{ L}) = 190. \text{ mm Hg}
\]

6) \( P_1 = 150 \text{ atm} \quad P_2 = 755 \text{ mm} \)

\( V_1 = 20. \text{ L} \quad V_2 = ? \)

\( T_1 = 30.^{\circ} \text{ C} + 273 = 303 \text{ K} \quad T_2 = 22^{\circ} \text{ C} + 273 = 295 \text{ K} \)

\[
P_1V_1/T_1 = P_2V_2/T_2
\]

\[
V_2 = P_1V_1/T_1 \times T_2/P_2
\]

\[
P_2 = 150 \text{ atm} \times 20. \text{ L} \times 295 \text{ K} / (303 \text{ K} \times 755 \text{ mm} \times 1 \text{ atm} / 760 \text{ mm}) = 2940 \text{ L}
\]

\# balloons = 1 balloon/5.0 \text{ L} \times 2940 \text{ L} = 588 \text{ balloons}